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1. A 1660–kg car travels at a speed of 12.5 m/s. What is its kinetic energy?

$$KE = \frac{1}{2}mv^2 = \left[\frac{1}{2}\right](1600\text{ kg})(12.5\text{ m/s})^2$$
$$= 1.25 \times 10^5\text{ J}$$

2. A racing car has a mass of 1500 kg. What is the kinetic energy if it has a speed of 108 km/h?

$$v = \frac{(108\text{ km/h})(1000\text{ m/km})}{(3600\text{ s/h})} = 30.0\text{ m/s}$$

$$KE = \frac{1}{2}mv^2 = \left[\frac{1}{2}\right](1500\text{ kg})(30.0\text{ m/s})$$
$$= 6.75 \times 10^5\text{ J}$$

3. Sally has a mass of 45 kg and is moving with a speed of 10.0 m/s.

a. Find Sally's kinetic energy.

$$KE = \frac{1}{2}mv^2 = \left[\frac{1}{2}\right](45\text{ kg})(10.0\text{ m/s})^2$$
$$= 2.3 \times 10^3\text{ J}$$

b. Sally's speed changes to 5.0 m/s. Now what is her kinetic energy?

$$KE = \frac{1}{2}mv^2 = \left[\frac{1}{2}\right](45\text{ kg})(5.0\text{ m/s})^2$$
$$= 5.6 \times 10^2\text{ J}$$

c. What is the ratio of the kinetic energies in a. and b.? Explain the ratio.

$$\frac{1/2(mv_1^2)}{1/2(mv_2^2)} = \frac{v_1^2}{v_2^2} = \frac{(10.0)^2}{(5.0)^2} = \frac{4}{1}$$

Twice the velocity gives four times the kinetic energy.

Chapter Review Problems

4. Shawn and his bike have a total mass of 45.0 kg. Shawn rides his bike 1.80 km in 10.0 min at a constant velocity. What is Shawn's kinetic energy?

$$v = \frac{d}{t} = \frac{(1.80\text{ km})(1000\text{ m/km})}{(10.0\text{ min})(60\text{ s/min})} = 3.00\text{ m/s}$$

$$KE = \frac{1}{2}mv^2 = \left[\frac{1}{2}\right](45.0\text{ kg})(3.00\text{ m/s})^2$$
$$= 203\text{ J}$$

5. It is not uncommon during the service of a professional tennis player for the racquet to exert an average force of 150.0 N on the ball. If the ball has a mass of 0.060 kg and is in contact with the strings of the racquet for 0.030 s, what is the kinetic energy of the ball as it leaves the racquet? Assume the ball starts from rest.

$Ft = m\Delta v = mv_f - mv_i$, and $v_i = 0$, so

$$v_f = \frac{Ft}{m} = \frac{(150.0\text{ N})(3.0 \times 10^2\text{ s})}{(6.0 \times 10^{-2}\text{ kg})}$$
$$= 75\text{ m/s}$$

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}(6.0 \times 10^{-2}\text{ kg})(75\text{ m/s})^2$$
$$= 1.7 \times 10^2\text{ J}$$

6. Pam has a mass of 40.0 kg and is at rest on smooth, level, frictionless ice. Pam straps on a rocket pack. The rocket supplies a constant force for 22.0 m and Pam acquired a speed of 62.0 m/s.

a. What is the magnitude of the force?

$F = ma$ and $v_f^2 = v_i^2 + 2ad$, so

$$a = \frac{v_f^2 - v_i^2}{2d} \text{ but } v_i = 0, \text{ so } a = \frac{v_f^2}{2d}$$

$$= \frac{(62.0\text{ m/s})^2}{2(22.0)} = 87.4\text{ m/s}^2. \text{ Therefore,}$$

$$F = ma = (40.0\text{ kg})(87.4\text{ m/s}^2)$$
$$= 3.50 \times 10^3\text{ N.}$$

b. What is Pam's final kinetic energy?

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}(40.0\text{ kg})(62.0\text{ m/s})^2$$
$$= 7.69 \times 10^4\text{ J}$$

Chapter Review Problems

7. Sally and Lisa have a mass of 45 kg and they are moving together with a speed of 10.0 m/s.

a. What is their combined kinetic energy?

$$KE_c = \frac{1}{2}mv^2 = \frac{1}{2}(m_s + m_l)(v^2)$$
$$= \frac{1}{2}(45\text{ kg} + 45\text{ kg})(10.0\text{ m/s})^2$$
$$= 4.5 \times 10^3\text{ J}$$

b. What is the ratio of their combined mass to Sally's mass?

$$\frac{m_s + m_l}{m_s} = \frac{45\text{ kg} + 45\text{ kg}}{45\text{ kg}} = \frac{90\text{ kg}}{45\text{ kg}} = \frac{2}{1}$$

c. What is the ratio of their combined kinetic energy to Sally's kinetic energy? Explain.

$$KE_s = \frac{1}{2}m_s v^2 = \frac{1}{2}(45\text{ kg})(10.0\text{ m/s})^2$$
$$= 2.25 \times 10^3\text{ J}$$
$$\frac{KE_c}{KE_m} = \frac{4.5 \times 10^3\text{ J}}{2.35 \times 10^3\text{ J}} = \frac{2}{1}$$

The ratio of the kinetic energies is the same as the ratio of their masses

8. In the 1950s an experimental train that had a mass of 2.50×10^4 kg was powered across a level track by a jet engine that produced a thrust of 5.00×10^5 N for a distance of 500 m.

a. Find the work done on the train.

$$w = F \cdot d = (5.00 \times 10^5\text{ N})(500\text{ m})$$
$$= 2.50 \times 10^8\text{ J}$$

b. Find the change in kinetic energy.

$$\Delta KE = w = 2.50 \times 10^8\text{ J}$$

c. Find the final kinetic energy of the train if it started from rest.

$$\Delta KE = KE_f - KE_i,\text{ so } KE_f = \Delta KE + KE_i$$
$$= 2.50 \times 10^8\text{ J} - 0$$
$$= 2.50 \times 10^8\text{ J}$$

d. Find the final speed of the train if there was no friction.

$$KE_f = \frac{1}{2}mv^2,\text{ so}$$
$$v^2 = \frac{KE_f}{1/2\,m}$$
$$= \frac{2.50 \times 10^8\text{ J}}{1/2(2.50 \times 10^4\text{ kg})}\quad\text{so}$$
$$v = \sqrt{2.00 \times 10^4\ m^2/s^2} = 141\text{ m/s}$$

9. A 14 700–N car is traveling at 25 m/s. The brakes are suddenly applied and the car slides to a stop. The average braking force between the tires and the road is 7100 N. How far will the car slide once the brakes are applied?

$$W = F \cdot d = \frac{1}{2}mv^2$$

$$\text{Now } m = \frac{w}{g} = \frac{14{,}700\text{ N}}{9.80\text{ m/s}^2} = 1500\text{ kg.}$$

$$\text{So } d = \frac{\frac{1}{2}mv^2}{F} = \frac{\frac{1}{2}(1500\text{ kg})(25\text{ m/s}^2)}{7100\text{ N}} = 66\text{ m.}$$

10. A 15.0-kg cart is moving with a velocity of 7.50 m/s down a level hallway. A constant force of –10.0 N acts on the cart and its velocity becomes 3.20 m/s.

a. What is the change in kinetic energy of the cart?

$$\Delta KE = KE_f - KE_i = \frac{1}{2}m(v_f^2 - v_i^2)$$
$$= \frac{1}{2}(15.0\text{ kg})[(3.20\text{ m/s})^2 - (7.50\text{ m/s})^2]$$
$$= -345\text{ J}$$

b. How much work was done on the cart?

$$W = \Delta KE = -345\text{ J}$$

c. How far did the cart move while the force acted?

$$W = Fd,\text{ so } d = \frac{W}{F} = \frac{-345\text{ J}}{-10.0\text{ N}} = 34.5\text{ m}$$

Chapter Review Problems

11. A 2.00×10^3–kg car has a speed of 12.0 m/s. The car then hits a tree. The tree doesn't move and the car comes to rest.

a. Find the change in kinetic energy of the car.

$$\Delta KE = KE_f - KE_i = \frac{1}{2}m(v_f^2 - v_i^2)$$
$$= \frac{1}{2}(2.00 \times 10^3 \text{ kg})(0^2 - (12.0 \text{ m/s})^2)$$
$$= -1.44 \times 10^5 \text{ J}$$

b. Find the amount of work done in pushing in the front of the car.

$$W = \Delta KE = -1.44 \times 10^5 \text{ J}$$

c. Find the size of the force that pushed the front of the car in 50.0 cm.

$W = F \cdot d$, so

$$F = \frac{W}{d} = \frac{-1.44 \times 10^5 \text{ J}}{0.500 \text{ m}}$$
$$= -2.88 \times 10^5 \text{ N}.$$

The negative sign implies a retarding force.

12. How much potential energy does Tim, mass of 60.0 kg, gain when he climbs a gymnasium rope a distance of 3.5 m?

$$PE = mgh = (60.0 \text{ kg})(9.80 \text{ m/s}^2)(3.5 \text{ m})$$
$$= 2.1 \times 10^3 \text{ J}$$

13. A 6.4–kg bowling ball is lifted 2.1 m into a storage rack. Calculate the increase in the ball's potential energy.

$$PE = mgh = (6.4 \text{ kg})(9.80 \text{ m/s}^2)(2.1 \text{ m})$$
$$= 1.3 \times 10^2 \text{ J}$$

14. Mary weighs 500 N. She walks down a flight of stairs to a level 5.50 m below her starting point. What is the change in Mary's potential energy?

$$\Delta PE = mg\Delta h = W\Delta h = (500 \text{ N})(-5.50 \text{ m})$$
$$= -2.75 \times 10^3 \text{ J}$$

15. A weightlifter raises a 180–kg barbell to a height of 1.95 m. What is the increase in the barbell's potential energy?

$$PE = mgh = (180 \text{ kg})(9.80 \text{ m/s}^2)(1.95 \text{ m})$$
$$= 3.44 \times 10^3 \text{ J}$$

16. A 10.0–kg test rocket is fired vertically from Cape Canaveral. Its fuel gives it a kinetic energy of 1960 J by the time the rocket motor burns all of the fuel. What additional height will the rocket rise?

$$PE = mgh = KE$$
$$h = \frac{KE}{mg} = \frac{1960 \text{ J}}{(10.0 \text{ kg})(9.80 \text{ m/s}^2)} = 20.0 \text{ m}$$

17. Ace raised a 12.0–N Physics book from a table, 75 cm above the floor, to a shelf, 2.15 m above the floor. What was the change in potential energy?

$$PE = mg\Delta h = W\Delta h = W(h_f - h_i)$$
$$= (12.0 \text{ N})(2.15 \text{ m} - 0.75 \text{ m}) = 16.8 \text{ J}$$

18. A hallway display of energy is constructed. People are told that to do 1.00 J of work, they should pull on a rope that lifts a block 1.00 m. What should be the mass of the block?

$W = \Delta PE = mgh$, so

$$m = \frac{W}{gh} = \frac{(1.00 \text{ J})}{(9.80 \text{ m/s}^2)(1.00 \text{ m})} = 0.102 \text{ kg}$$

19. A constant net force of 410 N, up, is applied to a stone that weighs 32 N. The upward force is applied through a distance of 2.0 m, and the stone is then released. To what height, from the point of release, will the stone rise?

$W = Fd = (410 \text{ N})(2.0 \text{ m}) = 8.20 \times 10^2 \text{ J}$.
But $W = \Delta PE = mg\Delta h$, so

$$\Delta h = \frac{W}{mg} = \frac{8.20 \times 10^2 \text{ J}}{32 \text{ N}} = 26 \text{ m}$$

20. A 98–N sack of grain is hoisted to a storage room 50 m above the ground floor of a grain elevator.

a. How much work was required?

$$W = Fd = (98 \text{ N})(50 \text{ m}) = 4.9 \times 10^3 \text{ J}$$

Chapter Review Problems

b. What is the potential energy of the sack of grain at this height?

$\Delta PE = W = 4.9 \times 10^3$ J

c. The rope being used to lift the sack of grain breaks just as the sack reaches the storage room. What kinetic energy does the sack have just before it strikes the ground floor?

$KE = \Delta PE = 4.9 \times 10^3$ J

21. A 20-kg rock is on the edge of a 100 m cliff.

a. What potential energy does the rock possess relative to the base of the cliff?

$$PE = mgh = (20 \text{ kg})(9.80 \text{ m/s}^2)(100 \text{ m}) = 2.0 \times 10^4 \text{ J}$$

b. The rock falls from the cliff. What is its kinetic energy just before it strikes the ground?

$KE = \Delta PE = 2.0 \times 10^4$ J

c. What speed does the rock have as it strikes the ground?

$$KE = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{(2)(2.0 \times 10^4 \text{ J})}{(20 \text{ kg})}} = 45 \text{ m/s}$$

22. An archer puts a 0.30-kg arrow to the bowstring. An average force of 201 N is exerted to draw the string back 1.3 m.

a. Assuming no frictional loss, with what speed does the arrow leave the bow?

$$W = KE$$

$$Fd = \frac{1}{2}mv^2$$

$$v^2 = \frac{2Fd}{m}$$

$$v = \sqrt{\frac{2Fd}{m}} = \sqrt{\frac{(2)(201 \text{ N})(1.3 \text{ m})}{(0.30 \text{ kg})}} = 42 \text{ m/s}$$

b. If the arrow is shot straight up, how high does it rise?

$$PE = \Delta KE$$

$$mgd = \frac{1}{2}mv^2$$

$$d = \frac{v^2}{2g} = \frac{(42 \text{ m/s})^2}{(2)(9.8 \text{ m/s}^2)} = 90 \text{ m}$$

23. A 2.0-kg rock initially at rest loses 400 J of potential energy while falling to the ground.

a. Calculate the kinetic energy that the rock gains while falling.

$$PE_i + KE_i = PE_f + KE_f$$
$$KE_f = PE_i = 400 \text{ J}$$

b. What is the rock's speed just before it strikes the ground?

$$KE = \frac{1}{2}mv^2, \text{ so } v^2 = (2)\frac{KE}{m} = \frac{(2)(400 \text{ J})}{(2.0 \text{ kg})} = 400 \text{ m}^2/\text{s}^2, \text{ so } v = 20 \text{ m/s.}$$

24. Betty weighs 420 N and is sitting on a playground swing seat that hangs 0.40 m above the ground. Tom pulls the swing back and releases it when the seat is 1.00 m above the ground.

a. How fast is Betty moving when the swing passes through its lowest position?

$$\Delta PE = Fd = (420 \text{ N})(0.40 \text{ m} - 1.00 \text{ m}) = -250 \text{ J}$$

$$KE = -\Delta PE = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{(2)(250 \text{ J})}{(420 \text{ N}/9.8 \text{ m/s}^2)}} = 3.4 \text{ m/s}$$

b. If Betty moves through the lowest point at 2.0 m/s, how much work was done on the swing by friction?

$$W = PE - KE = 250 \text{ J} - \frac{1}{2}mv^2$$

$$= 250 \text{ J} - \left[\frac{1}{2}\right]\left[\frac{420 \text{ N}}{9.80 \text{ m/s}^2}\right](2.0 \text{ m/s})^2$$

$$= 250 \text{ J} - 86 \text{ J} = 164 \text{ J} = 1.6 \times 10^2 \text{ J}$$

Chapter Review Problems

25. Bill throws a 10.0-g ball straight down from a height of 2.0 m. The ball strikes the floor at a speed of 7.5 m/s. What was the initial speed of the ball?

$KE_f = KE_i + PE_i$

$\frac{1}{2}mv_2^2 = \frac{1}{2}mv_1^2 + mgh$, the mass of the ball dividing out, so $v_1^2 = v_2^2 - 2gh$,

$v_1 = \sqrt{v_2^2 - 2gh}$

$= \sqrt{(7.5\ \text{m/s})^2 - (2)(9.80\ \text{m/s}^2)(2.0\ \text{m})}$
$= 4.1\ \text{m/s}$

26. Magen's mass is 28 kg. She climbs the 4.8-m ladder of a slide, then reaches a velocity of 3.2 m/s at the bottom of the slide. How much work was done by friction on Magen.

At the top,
$PE = mgh = (28\ \text{kg})(9.80\ \text{m/s}^2)(4.8\ \text{m})$
$= 1.3 \times 10^3\ \text{J}.$
At the bottom,

$KE = \frac{1}{2}mv^2 = \left[\frac{1}{2}\right](28\ \text{kg})(3.2\ \text{m/s})^2$

$= 1.4 \times 10^2\ \text{J}$
$W_f = PE - KE = 1.2 \times 10^3\ \text{J}$

27. A physics book, mass unknown, is dropped 4.50 m. What speed does the book have just before it hits the ground?

$KE = PE$

$\frac{1}{2}mv^2 = mgh$; the mass of the book divides out,

so $\frac{1}{2}v^2 = gh$, or

$\sqrt{2gh} = \sqrt{2(9.80\ \text{m/s}^2)(4.50\ \text{m})}$
$= 9.39\ \text{m/s}.$

28. A 30.0-kg gun is standing on a frictionless surface. The gun fires a 50.0-g bullet with a muzzle velocity of 310 m/s.

a. Calculate the momenta of the bullet and the gun after the gun was fired.

$P_g = -P_b$ and $P_b = m_b v_b$
$= (0.0500\ \text{kg})(310\ \text{m/s})$

$= 15.5\ \frac{\text{kg}\cdot\text{m}}{\text{s}}$

$P_g = -P_b = -15.5\ \frac{\text{kg m}}{\text{s}}$

b. Calculate the kinetic energy of both the bullet and the gun just after firing.

$KE_b = \frac{1}{2}mv^2 = \frac{1}{2}(0.0500\ \text{kg})(310\ \text{m/s})^2$

$= 2.40 \times 10^3\ \text{J}$
$P_g = mv$, so

$v = \frac{P_g}{m} = \frac{-15.5\ \frac{\text{kg}\cdot\text{m}}{\text{s}}}{30.0\ \text{kg}}$

$= 0.517\ \text{m/s}$

$KE_g = \frac{1}{2}mv^2 = \frac{1}{2}(30.0\ \text{kg})(0.517\ \text{m/s})^2$

$= 4.00\ \text{J}$

29. A railroad car with a mass of 5.0×10^5 kg collides with a stationary railroad car of equal mass. After the collision, the two cars lock together and move off at 4.0 m/s.

a. Before the collision, the first railroad car was moving at 8.0 m/s. What was its momentum?

$mv = (5.0 \times 10^5\ \text{kg})(8.0\ \text{m/s})$

$= 4.0 \times 10^6\ \frac{\text{kg}\cdot\text{m}}{\text{s}}$

b. What is the total momentum of the two cars after the collision?

Since momentum is conserved, it must be

$4.0 \times 10^6\ \frac{\text{kg}\cdot\text{m}}{\text{s}}$

Chapter Review Problems

c. Find the kinetic energies of the two cars before and after the collision.

Before the collision:

$KE_1 = \frac{1}{2}mv^2$

$= \left[\frac{1}{2}\right](5.0 \times 10^5 \text{ kg})(8.0 \text{ m/s})^2$

$= 1.6 \times 10^7 \text{ J}$

$KE_2 = 0$ since it is at rest.

After the collision:

$KE = \frac{1}{2}mv^2$

$= \left[\frac{1}{2}\right](5.0 \times 10^5 \text{ kg} + 5.0 \times 10^5 \text{ kg})(4.0 \text{ m/s})^2$

$= 8.0 \times 10^6 \text{ J}$

d. Account for the loss of kinetic energy.

While momentum was conserved during the collision, kinetic energy was not. The amount not conserved was turned into heat and sound.

30. From what height would a compact car have to be dropped to have the same kinetic energy that it has when being driven at 100 km/h?

$V = \left[100 \frac{\text{km}}{\text{h}}\right]\left[\frac{1000 \text{ m}}{1 \text{ km}}\right]\left[\frac{1 \text{ h}}{3600 \text{ s}}\right]$

$= 27.8 \text{ m/s}$

$KE = PE$

$\frac{1}{2}mv^2 = mgh$; the mass of the car divides out, so

$\frac{1}{2}v^2 = gh$, so $h = \frac{v^2}{2g} = \frac{(27.8 \text{ m/s})^2}{2(9.80 \text{ m/s}^2)} = 39.4 \text{ m}$

31. A golf ball, mass 0.046 kg, rests on a tee. It is struck by a golf club with an effective mass of 0.220 kg and a speed of 44 m/s. Assuming the collision is elastic, find the speed of the ball when it leaves the tee.

From conservation of momentum, $m_c v_c = m_c v_c' + m_b v_b'$. Solve for v_c',

$v_c' = v_c - \frac{m_b v_b'}{m_c}$.

From conservation of energy,

$\frac{1}{2}m_c v_c = \frac{1}{2}m_c(v_c')^2 + \frac{1}{2}m_b(v_b')^2$. Multiply by two and substitution gives

$m_c v_c^2 = m_c[v_c - \frac{m_b v_b'}{m_c}] + m_b(v_b')^2$, or $m_c v_c^2$

$= m_c v_c^2 - 2m_b v_b' v_c + \frac{m_b(v_b')^2}{m_c} + m_b(v_b')^2$.

Simplify and factor:

$0 = (m_b v_b')[-2v_c + \frac{m_b(v_b')}{m_c} + v_b']$. Either

$m_b v_b' = 0$ or $-2v_c + \left[\frac{m_b}{m_c} + 1\right]v_b' = 0$ so

$v_b' = \frac{2v_c}{\left[\frac{m_b}{m_c} + 1\right]} = \frac{2(44 \text{ m/s})}{\left[\frac{0.046 \text{ kg}}{0.220 \text{ kg}} + 1\right]} = 73 \text{ m/s}$

32. A steel ball has a mass of 4.0 kg and rolls along a smooth, level surface at 62 m/s.

a. Find its kinetic energy.

$$KE = \frac{1}{2}mv^2 = \left[\frac{1}{2}\right](4.0\ \text{kg})(62\ \text{m/s})^2$$

$$= 7.7 \times 10^3\ \text{J}$$

b. At first, the ball was at rest on the surface. A constant force acted on it through a distance of 22 m to give it the speed of 62 m/s. What was the magnitude of the force?

a. $W = Fd$

b. $F = \frac{W}{d} = \frac{7.7 \times 10^3\ \text{J}}{22\ \text{m}} = 3.5 \times 10^2\ \text{N}$

33. Show that $W = KE_f - KE_i$ if an object is not originally at rest. Use the equation relating initial and final velocity with constant acceleration and distance.

$v_f^2 = v_i^2 + 2ad$, or $d = \frac{v_f^2 - v_i^2}{2a}$. But

$$W = mad = ma\left[\frac{v_f^2 - v_i^2}{2a}\right] = \frac{1}{2}m(v_f^2 - v_i^2)$$

$= \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$. Therefore,

$W = KE_f - KE_i$.

Supplemental Problems (Appendix B)

1. Calculate the kinetic energy of a proton, mass of 1.67×10^{-27} kg, traveling at 5.20×10^7 m/s.

$$KE = \frac{1}{2}mv^2$$

$$= \frac{1}{2}(1.67 \times 10^{-27}\ \text{kg})(5.20 \times 10^7\ \text{m/s})^2$$

$$= 2.26 \times 10^{-12}\ \text{J}$$

2. What is the kinetic energy of a 3.2-kg pike swimming at 2.7 km/hr?

$$2.7\ \text{km/hr} \cdot \frac{1000\ \text{m}}{\text{km}} \cdot \frac{\text{hr}}{3600\ \text{s}} = 0.75\ \text{m/s}$$

$$KE = \frac{1}{2}mv^2 = \frac{1}{2}(3.2\ \text{kg})(0.75\ \text{m/s})^2 = 0.90\ \text{J}$$

3. A force of 30.0 N pushes a 1.5-kg cart, initially at rest, a distance of 2.8 m along a frictionless surface.

a. Find the work done on the cart.

$$W = Fd = (30.0\ \text{N})(2.8\ \text{m}) = 84\ \text{J}$$

b. What is its change in kinetic energy?

$$W = \Delta KE = 84\ \text{J}$$

c. What is the cart's final velocity?

$$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2(84\ \text{J})}{1.5\ \text{kg}}} = 11\ \text{m/s}$$

4. A bike and rider of 82.0-kg combined mass are traveling at 4.2 m/s. A constant force of −140 N is applied by the brakes in stopping the bike. What braking distance is needed?

$$KE = \frac{1}{2}mv^2$$

$$= \frac{1}{2}(82.0\ \text{kg})(4.2\ \text{m/s})^2$$

$= 723$ J of KE is lost

$(-140\ \text{N})d = -723\ \text{J}$

$d = 5.2\ \text{m}$

5. A 712-kg car is traveling at 5.6 m/s when a force acts on it for 8.4 s, changing its velocity to 10.2 m/s.

a. What is the change in kinetic energy of the car?

$$KE_{final} = \frac{1}{2}mv_f^2 = \frac{1}{2}(712\ \text{kg})(10.2\ \text{m/s})^2$$

$$= 3.7 \times 10^4\ \text{J}$$

$$KE_{initial} = \frac{1}{2}mv_i^2 = \frac{1}{2}(712\ \text{kg})(5.6\ \text{m/s})^2$$

$$= 1.1 \times 10^4\ \text{J}$$

$$\Delta KE = KE_{final} - KE_{initial} = 2.6 \times 10^4\ \text{J}$$

b. How far did the car move while the force acted?

$$d = \left[\frac{v_f + v_i}{2}\right]t = \left[\frac{10.2\text{ m/s} + 5.6\text{ m/s}}{2}\right](8.4\text{ s})$$
$$= 66\text{ m}$$

c. How large is the force?

$Fd = \Delta KE$
$F(66.4\text{ m}) = 2.6 \times 10^4\text{ J}$
$F = 3.9 \times 10^2\text{ N}$

6. Five identical 0.85-kg books of 2.50-cm thickness are each lying flat on a table. Calculate the gain in potential energy of the system if they are stacked one on top of the other.

Height raised:
book 1 none
book 2 2.5 cm
book 3 5.0 cm
book 4 7.5 cm
book 5 10.0 cm

25 cm total

$\Delta PE = mg\Delta h = (0.85\text{ kg})(9.80\text{ m/s}^2)(0.25\text{ m})$
$= 2.1\text{ J}$

7. Each step of a ladder increases one's vertical height 40 cm. If a 90.0-kg painter climbs 8 steps of the ladder, what is the increase in potential energy?

$(40\text{ cm})(8) = 320\text{ cm}$
$\Delta PE = mg\Delta h = (90.0\text{ kg})(9.80\text{ m/s}^2)(3.2\text{ m})$
$= 2.8 \times 10^3\text{ J}$

8. A 0.25-kg ball is dropped from a height of 3.2 m and bounces to a height of 2.4 m. What is its loss in potential energy?

$\Delta h = 2.4\text{ m} - 3.2\text{ m} = -0.80\text{ m}$
$\Delta PE = mg\Delta h = (0.25\text{ kg})(9.80\text{ m/s}^2)(-0.80\text{ m})$
$= -2.0\text{ J}$

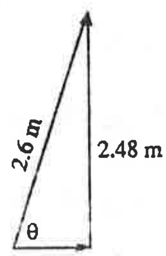
9. A 0.18-kg ball is placed on a compressed spring on the floor. The spring exerts an average force of 2.8 N through a distance of 15 cm as it shoots the ball upward. How high will the ball travel above the release spring?

$W = Fd$
$= (2.8\text{ N})(0.15\text{ m}) = 0.42\text{ J}$
$W = \Delta PE = mg\Delta h$
$0.42\text{ J} = (0.18\text{ kg})(9.80\text{ m/s}^2)(\Delta h)$
$\Delta h = 0.24\text{ m}$

10. A force of 14.0 N is applied to a 1.5-kg cart as it travels 2.6 m along an inclined plane. What is the angle of inclination of the plane.

$W = Fd = (14.0\text{ N})(2.6\text{ m}) = 36.4\text{ J}$
$W = \Delta PE = mg\Delta h$
$36.4k\text{ J} = (1.5\text{ kg})(9.80\text{ m/s}^2)(|h)$
$\Delta h = 2.48\text{ m}$

$\sin\theta = \frac{2.48}{2.6}$
$\theta = 72°$



11. A 15.0-kg model plane flies horizontally at a constant speed of 12.5 m/s.

a. Calculate its kinetic energy.

$$KE = \frac{1}{2}mv^2 = \left[\frac{1}{2}\right](15.0\text{ kg})(12.5\text{ m/s})^2$$
$$= 1.17 \times 10^3\text{ J}$$

b. The plane goes into a dive and levels off 20.4 m closer to Earth. How much potential energy does it lose during the dive? Assume no additional drag.

$\Delta PE = mgh = (15.0\text{ kg})(9.80\text{ m/s}^2)(20.4\text{ m})$
$= 3.00 \times 10^3\text{ J}$